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very large stipules resembling those of *P. Plattensis* and a large calyx which is strongly hirsute. From *P. Plattensis* and the other species of the group it differs in the stoutness of the plant, which is 3–6 dm. high and by the fewer (2–5 pairs) and larger leaflets, which are from 3–6 cm. long, and the acute teeth. It is a rare species. The only specimens seen are the following:

Washington: W. N. Suksdorf, no. 539. 1875.
Oregon: Elihu Hall, no. 135. 1871.
California: J. G. Lemmon, no. 1200. 1875.
British Columbia: John Macoun, no. 32. 1890.
Rocky Mountains of British America: E. Bourgeau, 1858.

Phyllotaxy as a Guide to Plant Analysis.

By A. L. Benedict.

There are few discrepancies in teaching more striking than the contrast between the elaborate discussion of leaf-arrangement in nearly all text-books and courses on Organography and the neglect of the subject in practical analysis.

Omitting the leaves of cryptogams and the coniferae, two methods of arrangement are found, the verticillate or whorled and the spiral, alternate or scattered. The words verticillate and whorled are really the same, if we seek their root. The term *scattered* is highly objectionable, since it suggests that the leaves occur haphazard, but nowhere in botany is a more exact mathematical system followed than in the putting forth of leaves. The term *alternate* should, from its meaning, be limited to the simplest variety of spiral phillotaxy, in which the leaves occur, first on one side and then on the other, of the stem.

If we conceive the outer layer of the stem to be made up of a number of columns of cells, we have a simple and lucid explanation of the decussation of adjacent whorls and of the spiral line in which leaves are otherwise thrown out. The development of a leaf involves a tremendous expenditure of vitality and it is easy to understand why one whorl of leaves should issue from the columns which have rested during the formation of the preceding whorl, and why, in the other form of phyllotaxy, the effort should take place in relays till the first column is again reached.

Considering the number of primitive leaves in the seed, it is obvious that we must regard the normal phyllotaxy of exogens as originally whorled and with two leaves in a whorl, while the leaves of endogens have, at first, a spiral arrangement. This conception, however, must not be taken as a practical guide for the study of mature plants, as it would prove misleading in a large proportion of cases. It is also obvious that the flower is, in nearly every instance, a compact series of whorls, whatever the arrangement of the foliage leaves.

The whorled phyllotaxy is very simply subdivided, according to the number of leaves in a circle. This number, omitting the primitive leaves and the flowers, is the same for every whorl of any individual, although it may differ in individuals of the same species. For example, I have found growing within a few feet of one another, *Eupatoria* with five, six and seven leaves, respectively, in a whorl; yet all were of the same species (*E. purpureum*, I believe) and, from their proximity, may very probably have grown from seeds of the same plant. Like almost every botanical feature not connected with the flower, phyllotaxy is a very unreliable guide to generic and family grouping. Thus, all the mints have opposite leaves, but the closely-allied family of figworts includes examples of both general kinds of phyllotaxy; none of the genera of the composite family embrace species illustrating both kinds, but the genus *Cornus* includes both alternate-leaved and opposite-leaved dog-woods.

My notes on phyllotaxy as a guide to analysis, relate almost without exception to the trees of North-eastern America, and are supplementary to the excellent table of Charles S. Newhall. All subsequent statements, must, therefore, be understood with this qualification.

First of all, is to be noted a great preponderance of the spiral phyllotaxy, there being only seven genera represented, with opposite leaves—*Acer*, *Negundo*, *Fraxinus*, *AEsculus*, *Viburnum*, *Chionanthus*, and the single species, *florida*, of *Cornus*. *Catalpa* is the only instance of a tree with more than two leaves in a whorl, having usually three (but sometimes only two.—Wood).

Although not strictly belonging in a discussion of phyllotaxy, the arrangement of leaflets is an interesting and valuable guide to the study of our native trees. The palmately compound leaf is represented only by the genus *AEsculus*, whose leaves are also opposite. Of the trees with pinnately compound leaves, only two genera, *Fraxinus* and *Negundo*, belong to the opposite-leaved group, and of all the trees with compound leaves there are but two with abruptly pinnate leaves, namely, *Gleditschia* and *Gymnocladus*, in which the compounding is also carried to the second or third degree.

The spiral phyllotaxy is subdivided according to the number of leaves in a series, which may be considered as a whorl lengthened out by the growth of the stem between the times at which leaves were put forth. The beginnings of the several series—or, of course, any corresponding leaves of different series—are in the same perpendicular column. A series of any particular number of leaves is also included in a certain number of spiral turns about the stem. Thus, the simplest series has its leaves arranged 1–2, 1–2, each leaf being half a circumference from the next and the series of two leaves being completed in one turn. The next series runs 1–2–3, 1–2–3, each leaf being a third of a circumference from its neighbor, so that this series is also completed in one spiral turn. The next series contains five leaves, but each is $\frac{2}{5}$ instead of $\frac{1}{5}$ of a circumference from the next leaf above or below, so that the series requires two turns about the stem before we reach a leaf directly above no. 1. It will be noticed that nature has apparently formed this third series by adding together the number of turns and the number of leaves of the two preceding series, just as little children would add the fractions $1/2$ and $1/3$, numerator to numerator and denominator to denominator, and get the result $\frac{2}{5}$. The next series, characterized by eight leaves and three spiral turns, seems, likewise, to have been formed by adding the one-turn and three-leaf series to the two-turn and five-leaf series. A series higher still has $2 + 3$ turns and $5 + 8$ leaves. Beyond this, we may still imagine nature continuing to add numerator to numerator and denominator to denominator, but the leaves become so densely crowded, that we cannot bring them into order and, hence, we term the arrangement a fascicle, or *bunch* to translate literally. It should be remembered that Nature never adds any but consecutive series together, and this is the best possible support of our theory, that one series really is joined with the next one, the distance between the adjacent leaves being averaged so that each successive fraction represents the numerator to numerator and denominator to denominator addition of the two next simpler series.

The elms, hornbeam, hop-hornbeam and beeches form a group by themselves. All have simple leaves, of about the same general outline, ovate or quite broadly elliptical, with acuminate apices, rounded bases and serrated margins, those of the elms and the hornbeam being bi-serrate, and, most remarkable of all, every one of this group has its leaves arranged on the $\frac{1}{2}$-spiral plan, with the additional peculiarity that the leaves of a branch lie in the same plane with the stem, as if already pressed. The basswood, buttonwood and mulberries have the same flattened spray, but the similarity of the individual leaves is not marked. The mulberries are like the sassafras in having leaves of different shapes, some being broadly ovate, others resembling mittens, others being best described as " double-thumbed" mittens. In following out a young branch—this phenomenon is not so distinct on older trees—the first leaves are of simple outline, then the thumb is formed on the side of the leaf away from the branch, then follows a similar mitten, but the two are right and left-handed, then a pair of leaves with " thumbs" on both sides of the leaf, then a pair again right and left, with two fingers on the outer side and one on the inner side. Almost exactly the same arrangement may be seen on the sassafras. It seems that nature, setting out with a very simple plan, keeps improving upon it, always adding the variations on the side away from the branch, so that there results a succession of pairs of leaves, identical except for being right and left-handed. So far as I know, no other native tree has leaves of different pattern, save for the slight variations always seen in natural objects of any kind.

The study of the higher spirals is attended with considerable difficulty, the branches from which no leaves are missing being quite short, so that the leaves are apparently crowded into a fascicle, while older branches are apt to be deformed by accidents. It is to be noted, also, that Nature seems to have followed in practice the theory by which we have explained her curious development of series. For example, a short willow branch seems to exemplify the $1/3$ phyllotaxy, but a longer stem plainly shows a $\frac{2}{5}$ arrangement. The plum and apple, similarly, are promoted by the careful student from the $\frac{}{5}$ class to the $3/8$ class; and the walnut and butternut, which we are at first tempted to consider examples of the $3/8$ spiral, belong at least to the $\frac{5}{13}$ series, and the suspicion grows on us that, if we could find a perfect branch with a large number of leaves on it, we might ascend still higher in the range of spiral series. But it is of analytical value to be able to assign a plant to a place in one of two series, just as it is helpful to be able to say, " such a leaf has from five to seven pairs of leaflets."

The tulip tree, oaks, hickories, staghorn sumach and alternate leaved dogwood (the last two being arborescent) have the $\frac{2}{5}$ arrangement quite distinctly. In other instances the results were so conflicting, or the practical difficulties of obtaining good specimens were so great, that the summer closed before I could reach definite conclusions, if, indeed, it is possible to ascribe plants to certain series in all instances.

With the exception of the dogwoods, variations in phyllotaxy never cross generic lines and seldom if ever infringe upon the limits of families.

Reinke's Discussions of Lichenology.

By Albert Schneider.

It is thought advisable to give a review of Reinke's paper on lichenology, because this author is doubtless the most competent advocate of modern scientific lichenology. Although much of the author's discussion is based upon theory and the observations of others, yet the papers are of inestimable value to the special student, and we hope that they will be collected and issued in book form. Meanwhile it is hoped that this review may be found useful by those English-speaking students who can not readily avail themselves of the original communications.